The gas produced in the burning of sulphur ores, when issuing from the burner, holds in mechanical suspension a considerable quantity of “ flue-dust," which must be removed as far as is practic­able before the gas is subjected to further treatment. Flue-dust contains principally ferric oxide, zinc oxide, arsenious and sulphuric acids, and small quantities of the various metals occurring in the raw ore. All the thallium and selenium on the market is obtained from this source. Sometimes the burner-gas is employed directly for the sake of the SO2 which it contains, principally in the manu­facture of “ sulphite cellulose ” from wood. When the gas is to be utilized for the manufacture of sulphuric acid the SO2 must be combined with more oxygen, for which purpose an “ oxygen carrier ” must be employed. Until recently the only agent practically used for this purpose was furnished by the oxides of nitrogen; more recently other oxygen carriers, acting by “ contact processes,” have also come into use (see below).

The production of sulphuric acid by the assistance of the oxides of the nitrogen is carried out in the “ vitriol chambers.” These are immense receptacles, mostly from too to 200 ft. long, 20 to 30 ft. wide, and 15 to 25 ft. high, constructed of sheet-lead, the joints of the sheets being made by " burning ” or autogenous soldering, *i.e.* fusing them together by a blow-pipe without the aid of solder (which would be quickly destroyed by the acid). The vitriol chambers must be supported on all sides by suitable wooden or iron framework, and they are always erected at a certain height over the ground, so that any leaks occurring can be easily detected. In nearly all cases several of these chambers are connected so as to form a set of a cubic capacity of from 100,000 to 200,000 cub. ft. The burner gas is introduced at one end, the waste gases issue from the other, the movement of the gases being impelled partly by their own chemical reactions, partly by the draught produced by a chimney (or tower), or by mechanical means. At the same time water is introduced in a number of places in the shape of steam or finely divided as a spray, to furnish the material for the reaction : SOs + O + H2O = H2SO4. As this reaction of its own accord takes place only to a very small extent, an “ oxygen carrier ” is always introduced in the shape of the vapours of nitric acid or the lower oxides of nitrogen. By the play of reactions induced in this way practically the whole of the SO4 is ultimately converted into sulphuric acid, and at the same time the nitrogen oxides are always recovered with comparatively very slight losses and made to serve over again.

The reactions taking place in the vitriol chambers are very complicated, and have been explained in many different ways. The view hitherto accepted by most chemists is that developed by G. Lunge, according to which there are two principal reactions succeeding each other, it may be in quite contiguous places, but under different conditions. Where the nitrous fumes prevail and there is less water present, sulphur dioxide combines with nitrous acid and oxygen to form nitroso-sulphuric acid, a crystalline sub­stance of the formula SO2(OH)(ONO). The reaction is therefore: SOi + O + HNO+2 = SO5NH. The solid substance is, however, only exceptionally met with, as it at once dissolves in the mist of sulphuric acid floating in the chamber and forms " nitrous vitriol.” Wherever this nitrous vitriol comes into contact with liquid water *(not* steam), which is also present in the chamber in the shape of mist, and practically as dilute sulphuric acid, it is decomposed into sulphuric and nitrous acid, thus: SO2(OH)(ONO) + H2O = H2SO4 + HNO2. The re-formed nitrous acid, although not stable, any more than is its anhydride, N2O3, is nevertheless the " oxygen carrier ” in question, as the products of its spontaneous decomposition, when meeting with other compounds, always react like nitrous acid itself and thus may transfer an indefinite quantity of oxygen to the corresponding quantities of SO2 and H2O, with the corresponding formation of H2SO4. This theory at once explains, among other things, why the acid formed in the vitriol chambers always contains an excess of water (the second of the above-quoted reactions requiring the " mass action ” of this excess), and why the external cooling produced by the contact of the chamber sides with the air is of great importance *(liquid* water in the shape of a mist of dilute sulphuric acid being necessary for the process).

In 1906 Lunge (in a paper published with Bert) to some extent modified his views, by introducing an intermediate compound, sulphonitronic acid, SO5NH2, which had been noticed by various chemists for some time through its property of imparting a deep blue colour to sulphuric acid. It is evident that the “ nitrous gases ” present in the vitriol chamber consist essentially of a mixture of NO and NO2, the latter being formed from NO by the excess of oxygen present. The NO2 (or NO + O) reacts upon SO2 + H2O, forming SO3NH2, which, being extremely unstable, is at once oxidized to SO5NH (nitroso-sulphuric acid). The latter is now either con­verted by hydrolysis into sulphuric acid and nitrogen oxides: 2SO5NH + H2O = 2H2SO4 + NO + NO2, the latter acting as before: or it reacts with more SO2, forming again sulphonitronic acid: 2SO5NH + SO2 + 2H2O = H2SO4 4- 2S05NH2. The latter can also split up directly into NO and SO4H2.

Whatever be the true theory of the vitriol-chamber process, there is no doubt about the way in which the reactions have to be carried out in practice. Since the reactions occur among gases and liquids in the nebulous state, vast spaces have to be provided in which the process may be carried out as completely as possible before the waste gases are allowed to escape into the outer air. These spaces cannot be constructed in any other way than is actu­ally done in the shape of the lead chambers; neither iron nor brick­work can be employed for this purpose, as they would be quickly destroyed by the acid liquids and gases.

When issuing from the chambers, the gases still contain the whole of the free nitrogen contained in the air which had entered into the burners, together with about a third, or at least a fourth, of the oxygen originally present therein, such excess of oxygen being required in order to carry out the conversion of the sulphur dioxide into sulphuric acid as completely as possible. For similar reasons it is necessary to employ much more water than is required to form H2SO4; and this is all the more necessary as strong sulphuric acid dissolves the nitrous compounds in the shape of nitroso-sulphuric acid, and thus withdraws these oxygen carriers from the gas-space of the chambers where the necessary reactions take place. It follows from this that the acid collecting at the bottom of the chambers must never exceed a certain concentration, say 70%, H2SO4 having a specific gravity of 1∙615, but it is preferable to make it only 66 to 67%, having a specific gravity of 1∙57 to 1∙58. On the other hand, it should never go down below 60 % H2SO4, equivalent to a specific gravity of 1∙50.

The commercial production of sulphuric acid imperatively requires that the nitrogen oxides (which originally were always introduced in the shape of nitric acid) should be available as long as possible, before being lost mechanically or by reduction to the inactive forms of nitrous oxide or elementary nitrogen. The first step towards securing this requirement was taken as early as 1827 by Gay-Lussac, who discovered that the nitrous fumes, otherwise carried away from the lead chambers by the waste atmo­spheric nitrogen and oxygen, could be retained by bringing the gases into contact with moderately strong sulphuric acid, the result being the formation of nitroso-sulphuric acid : 2H2SO4 + N2O2 = 2SO2(OH)(ONO) + H2O, and the latter remaining dissolved in sulphuric acid as “ nitrous vitriol.” But this important invention was of little use until John Glover, about 1866, found that the nitrous vitriol could be most easily reintroduced into the process by subjecting it to the action of burner-gas before this enters into the lead chambers, preferably after diluting it with chamber acid, that is, acid of from 65 to 70%, H2SO4, as formed in the lead chambers. The reaction is then: 2SO2(OH)(ONO) + SO2 + 2H2O = 3H2SO4 + 2NO; that is to say, all the “nitre” is returned to the chambers in the shape of NO; the sulphuric acid employed in the Gay-Lussac process is not merely recovered, but an additional quantity is formed from fresh SO2; as the heat of the burner-gases also comes into play, much water is evaporated, which supplies part of the steam required for the working of the chambers; and the acid issues from the apparatus in a “ denitrated ” and sufficiently concentrated state (78 to 80% H2SO4) to be used over again for absorbing nitrous vapours or any other purpose desired. Since that time, in every properly appointed sulphuric acid manufactory, the following cycle of operations is carried out. To begin with, in the burners pyrites (or, as the case may be, brimstone or blende) is made to yield hot burner-gas containing about 7 % (in the case of brimstone 10 or 11 %) of SO2. This, after having been deprived of most of the flue-dust, is passed through the " Glover tower,” *i.e.* an upright cylindrical or square tower, consisting of a leaden shell lined with heat- and acid-proof stone or brick, and loosely filled or “ packed ” with the same material, over which a mixture of acid from the Gay-Lussac tower and from the chambers trickles down in such proportions that it arrives at the bottom as denitrated acid of from 78 to 80% H2SO4. The gases now pass on to the lead chambers, described above, where they meet with more nitrous vapours, and with steam, or with water, converted into a fine dust or spray. Here the reactions sketched above take place, so that " chamber-acid ” as already described is formed, while a mixture of gases escapes containing all the atmospheric nitrogen, some oxygen in excess, about 0∙5 % of the total SO2, and some oxides of nitrogen. This gas is now passed through the Gay-Lussac tower, which somewhat resembles the Glover tower, but is usually filled with coke, over which sulphuric acid of about 80% H2SO4 trickles down in sufficient quantity to retain the nitrous vapours. Ulti­mately the waste gas is drawn off by a chimney, or sometimes by mechanical means.

Of course a great many special improvements have been made in the plant and the working of chamber systems ; of these we mention only some of the most important. By judiciously watching all stages of the process, by observing the draught, the strength of the acid produced, the temperature, and especially by frequent analyses of the gases, the yield of acid has been brought up to 98% of the theoretical maximum, with a loss of nitre sometimes as low as two parts to 100 of sulphur burned. The supply of the nitric acid required to make up this loss is obtained in England by " potting ” that is, by decomposing solid nitrate of soda by sulphuric acid in a flue between the pyrites burners and the chambers. On the continent of Europe makers generally prefer to employ liquid nitric acid, which is run through the Glover tower together